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COMBAT DAMAGE ASSESSMENT TEAM, A-10/6AU-8 LOW ANGLE FIRINGS VER--ETC(U)

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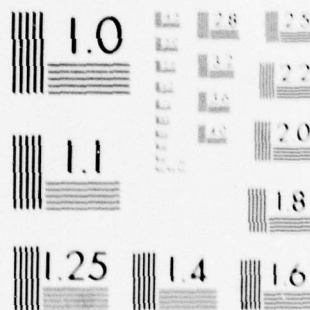
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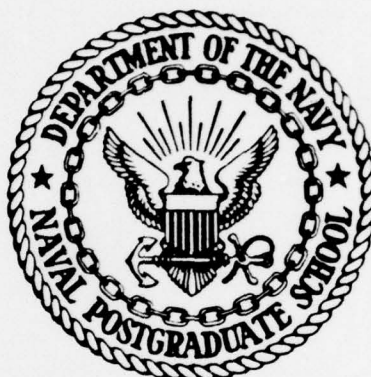
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COMBAT DAMAGE ASSESSMENT TEAM
A-10/GAU-8 LOW ANGLE FIRINGS
VERSUS
SIMULATED SOVIET TANK COMPANY
(10 MARCH 1978)

R.H.S. Stolfi

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August 1979

Approved for public release; distribution unlimited.

Prepared for: A-10 System Program Office
Wright-Patterson Air Force Base
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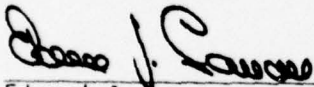
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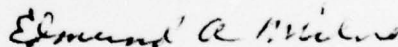
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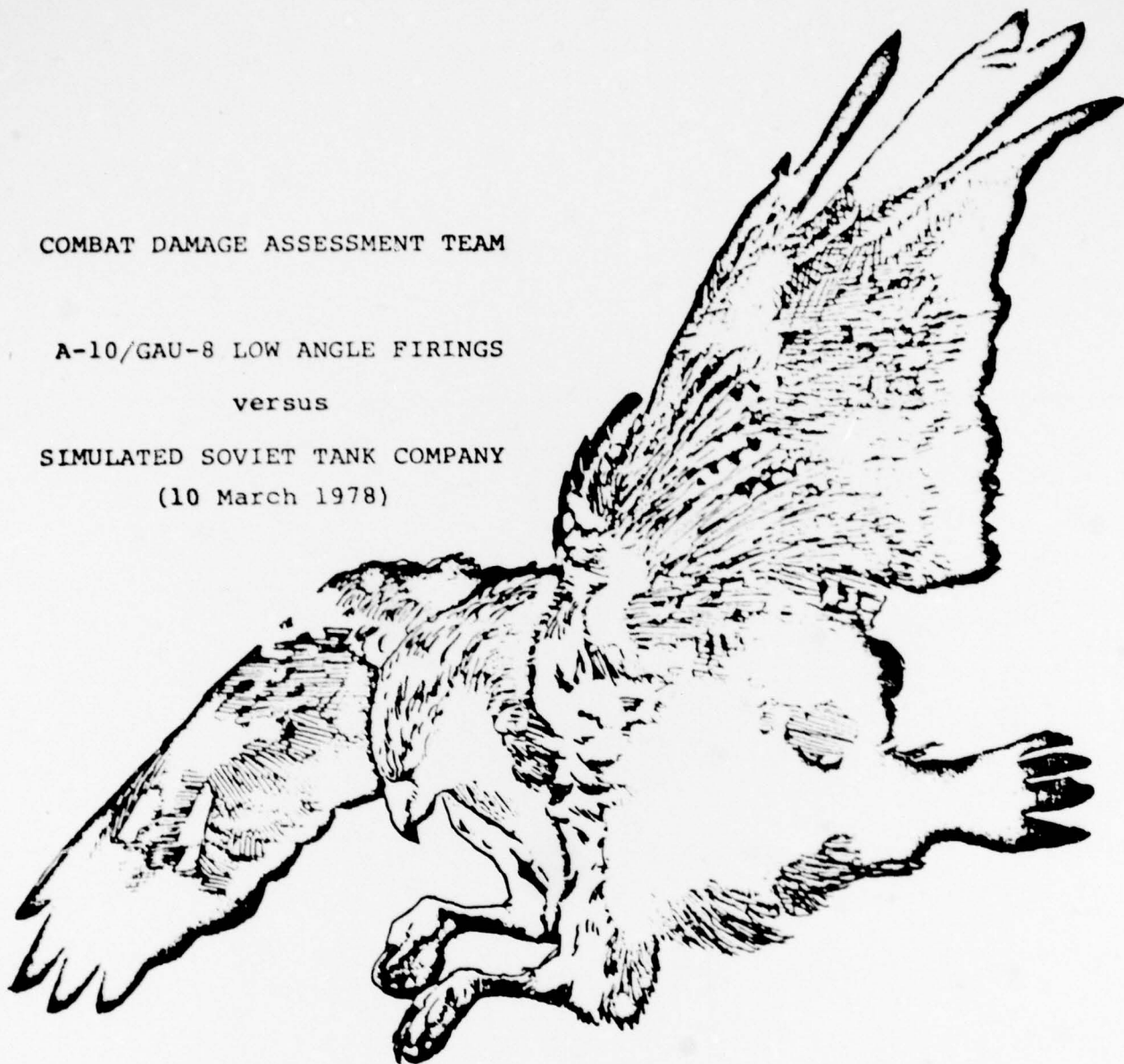
COMBAT DAMAGE ASSESSMENT TEAM

A-10/GAU-8 LOW ANGLE FIRINGS

versus

SIMULATED SOVIET TANK COMPANY

(10 March 1978)



EXECUTIVE SUMMARY



EXECUTIVE SUMMARY

Under the technical direction of the Combat Damage Assessment Committee (CDAC), the Combat Damage Assessment Team (CDAT) conducted firings of the A-10/GAU-8 weapon system against an array of 10 tanks simulating a Soviet tank company deployed for an attack. The CDAT used M-47 tanks stowed with ammunition, diesel fuel, lubricating oil, and crew mannikins to simulate the Soviet tanks. The pilots of the two A-10 aircraft used in the firings conducted their attack at low altitudes and low dive angles simulating approach and attack below the altitudes of effective engagement for an opposing air defense network employing acquisition and fire control radar. The purpose of the test was to evaluate the effects of the 30mm APIT antitank ammunition of the GAU-8 gun under stringent conditions of engagement for the A-10/GAU-8 system against simulated Soviet main battle tanks.

The Combat Damage Assessment Committee assessed the results of the low angle cannon firings of the two A-10 aircraft against the simulated Soviet tank company as follows:

1. Attack Parameters: The pilots flew combat two ship tactics remaining below 300 feet altitude for the entire attack. To minimize exposure to an assumed air defense threat and the targets ability to significantly improve its posture during the attack, all firing passes were compressed into a time span of 4 minutes and 12 seconds. The attack dive angles averaged 3.2 during 12 passes on the targets. The pilots opened fire at slant ranges which averaged 3493 feet and ceased fire at ranges which averaged 2404 feet, and fired 1684 rounds in 12 bursts averaging 2.08 seconds each.

2. Weapon Effects: The A-10/GAU-8 weapon system achieved 253 impacts on the 10 tank targets. The ratio of impacts to total rounds fired was 0.15. The weapon system achieved 43 perforations of the armored envelopes of the tanks with a ratio of perforations to impacts of 0.17. Many projectiles, which did not perforate armor, severely damaged exterior track and suspension components of the tanks.

3. Damage Assessment: The attacking A-10/GAU-8 weapon system inflicted eight 100% Mobility Kills of which four were also catastrophic K-Kills in the company array of ten tanks. The remaining 2 tanks escaped with light mobility damage.

4. Test Conditions: Ceiling and visibility were unlimited during the firing and the target tanks were sited in open, flat desert terrain. After the first two passes, black smoke from

catastrophically destroyed tanks was evident but did not appear to adversely effect pilot gunnery during the remaining passes.

5. Conclusions: The A-10/GAU-8 weapon system either catastrophically destroyed or immobilized 8 of 10 combat loaded M-47 tanks. The observed and documented results support the conclusion that:

a. GAU-8 30mm APIT projectiles are lethal against M-47 and similarly protected tanks, e.g., Soviet T-55 and T-62 tanks, under challenging and realistic firing conditions.

b. GAU-8 30mm APIT projectiles can inflict catastrophic and immobilizing damage on main battle tanks (MBTs) in low level attacks against the sides and rear of such heavily armored targets. The mission indicated that a two ship flight possesses the required firepower to destroy the operational effectiveness of a tank company formation.

c. From the viewpoint of target kills and ammunition effectiveness, the attack parameters employed in the test appear to be satisfactory in the attack of heavily armored targets. Low altitude attacks have essentially the same effectiveness as higher attack angles.

d. The rapidity of the attack indicates the A-10/GAU-8 weapons systems ability to destroy a perishable multi-target formation (i.e., one with high mobility that can rapidly disperse, move to cover, or maneuver to interrupt line-of-sight observation from the attacking aircraft).

6. The overall results of the test are summarized in Table I. Column one in the table shows that the A-10 aircraft made 12 passes, and column two shows that the aircraft fired against 10 tanks designated numbers 1-10. Column two also shows that several of the tanks were impacted in more than one firing pass either as primary, secondary or incidental targets. The CDAT was unable to correlate 20 observed impacts with a given firing pass and, thus, the bottom row of the table shows those impacts associated with the three targets which they struck but otherwise undifferentiated.

TABLE 1

SUMMARY OF ATTACK PARAMETERS AND DAMAGE ASSESSMENT
SIMULATED SOVIET TANK COMPANY, 10 MARCH 1978
(TOTAL TIME OF ATTACK, 4 MIN. 12 SEC.)*

A-10 PASS NO.	TANK TARGET NO.	ATTACK ASPECT (°)	SLANT RANGE (FEET) OPEN	DIVE ANGLE (°)	BURST LENGTH (SEC)	ROUNDS FIRED TOTAL	IMPACTS	PERFS	KILL ASSESSMENT			TOTAL TANKS IMMOB
									M	F	K	
1	1	270	?	?	***	***	23	7	--	--	100	X
	2	270	3670	4.7	2.40	163	10	1	--	--	--	--
	3	270	?	?	***	***	13	3	--	--	--	--
2	8	270	?	?	†	†	5	0	--	--	--	--
	9	270	?	?	†	†	27	5	--	--	--	--
	10	270	3490	4.0	2.27	154	33	11	--	--	100	X
3	7	190	4261	1.4	3.04	208	24	1	100	--	--	X
4	8	225	4130	6.6	1.35	90	20 ⁺⁺	3	--	--	100	X
5	6	180	3482	2.2	2.49	166	13	1	100	--	--	X
6	9	230	?	?	1.46	97	14	1	--	--	100	X
7	5	180	2846	2.6	1.31	87	6	0	5	--	--	--
8	3	225	3134	1.3	1.94	131	10	1	100	40	--	X
9	4	145	3404	3.4	2.06	139	12	0	5	--	--	--
10	1	225	2268	?	1.88	126	6	0	--	--	--	--
11	2	160	4016	6.1	2.67	182	17	6	100	5	--	X
12	8	225	3636	1.4	2.08	141	--	--	--	--	--	--
?	1, 3, 9	?	?	?	?	?	20	3	--	--	--	--
12	10	TOTALS OR AVERAGES	3307	3.2	2.08	1684	253	43	4	TANKS K-KILLED 8 TANKS IMMOBILIZED (X)		

* REFERENCE: Kevin Gravois et al., Results of the A-10A Combat Lethality Assessment Test of 10 March 1978, General Electric, Burlington, Vermont, 11 Aug 1978, and field notes of the Post strike Damage Assessment and Test Data groups.

** At open fire.

*** Target 2 was primary target.

† Target 10 was primary target.

†† Total, passes 4 and 12.

APPENDIX A

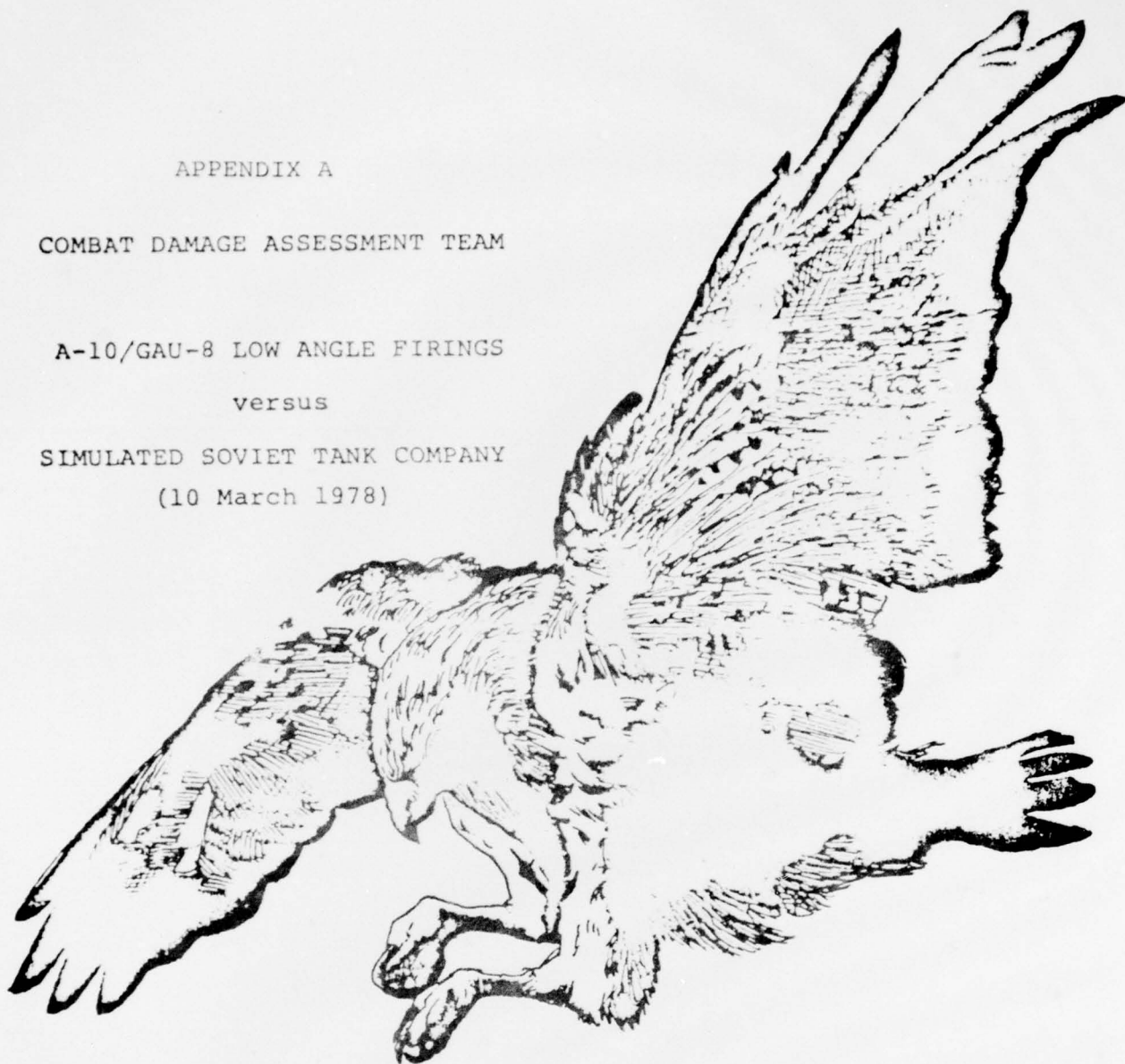
COMBAT DAMAGE ASSESSMENT TEAM

A-10/GAU-8 LOW ANGLE FIRINGS

versus

SIMULATED SOVIET TANK COMPANY

(10 March 1978)



REPORT



REPORT

I. Background

Since February 1978, the Armament Directorate, A-10 System Program Office, Wright Patterson Air Force Base, Ohio, has conducted firing tests using the A-10/GAU-8 system in low level, air-to-ground engagements of armored targets. The tests have been conducted within the framework of the GAU-8 30mm ammunition Lot Acceptance Verification Program (LAVP) - Airborne. The LAVP has the following objectives which apply to the present tests:

A. To evaluate the performance of existing production lots of GAU-8 ammunition when fired from the air under operational conditions.

B. To evaluate the lethality of GAU-8 ammunition against armored targets when fired at low level from A-10 aircraft using operational tactics.

To conduct the LAVP program, the Armament Directorate has cooperated with Headquarters, Tactical Air Command, Langley AFB, Virginia and with the Tactical Fighter Weapons Center, Nellis AFB, Nevada. Within the framework of that cooperation, the Armament Directorate has set up a Combat Damage Assessment Team (CDAT) to plan and execute the firing tests and evaluate the results. The CDAT functions under the direction of a Combat Damage Assessment Committee (CDAC) which has prepared this report.

II. Test Philosophy

To generate realistic data, the CDAT determined to use a highly empirical technique of destructive testing of actual target tanks. Tests have involved firings at individual tanks in November 1977 and February - March 1978. The experimental setup for the firings of 10 March 78 involved the first use of a multitarget, tactically arrayed tank formation for attack by the A-10/GAU-8 system. The CDAT elected to simulate a Soviet tank company as organized within a tank division as the target array for two attacking A-10 aircraft. As few constraints as possible were placed on the attacking pilots in an attempt to develop as much realism as possible. Figure 1 shows the test factors which would have been ideal, and the practicable setup which was achieved.

FIGURE 1

Empirical Test Philosophy

Comparison of Ideal & Practicable Test Situations

<u>Ideal Test Parameters</u>	<u>Practicable Test Parameters</u>
1. Air Attack Realism	1. Air Attack Realism
a. Actual A-10/GAU-8-----	a. Actual A-10/GAU-8
b. 30mm APIT-----	b. 30mm APIT
c. European Weather & ----- Terrain	c. Nevada desert terrain and Weather
d. Optimum open fire----- ranges (2000 feet)	d. Long open fire ranges (4000-3000 ft safety constraints)
e. Low altitude attack----- (<5° Dive Angle)	e. Low altitude attack (<5° Dive Angle)
2. Air Defense Realism	2. Air Defense Realism
a. Automatic cannon firing--- at A/C	a. Low altitude, low angle, minimum exposure attacks vs assumed AD system
b. Missile systems firing---- at A/C	b. Ditto
c. Small arms firing at A/C--	c. Ditto
d. AD suppression by A/C-----	d. No suppression simulation in test
3. Threat Targets and Doctrine	3. Threat Targets and Doctrine
a. T62/T64/T72 high fidelity- targets	a. Simulated Soviet Tanks
b. Stowed combat loads----- (in T-62/T-64/T72)	b. Stowed combat loads (in US M-47)
c. Realistic crew station---- postures	c. Wooden crew mannikins
d. Dynamic combat formation--	d. Static combat formation
e. Maneuvering evasive----- targets	e. Stationary targets

III. The Simulated Ground Combat Situation

The firing test of 10 March 1978 consisted of an attack by two A-10 aircraft on a simulated Soviet tank company. The scenario depicted a Soviet tank company in the role of a lead march security detachment (LMSD) for its battalion, which in turn, is the advance guard of a larger mobile formation. The LMSD is operating approximately five kilometers in front of the battalion column. The mission of the LMSD is to ensure the uninterrupted advance of the battalion and provide security against attack. Upon meeting heavy resistance, the company deploys into an appropriate combat formation to reduce the resistance or form a base of fire for offensive action by the remainder of the battalion.

One of the most important missions of the A-10 aircraft is the blunting of armored spearheads in conjunction with U.S. and allied ground forces. The airborne speed and range of the A-10 gives it the flexibility to intervene against deeply penetrating enemy armor in support of hard pressed ground forces unable to move the approximate ground strength. Under such tactical circumstances, it becomes particularly important for the A-10 to slow or halt advancing armor in order that (1) ground forces can mass to counter the breakthrough, and (2) ground forces can increase their antitank effectiveness by engaging slowed or immobilized enemy armor. In the firing test of 10 March 78, the attacking A-10 aircraft immobilized eight out of ten simulated Soviet tanks in 4 min., 12 sec.

A Soviet tank company, operating as simulated in the firing test, would probably have other units attached to it for its support. Attached units might include any one or all of the following elements: (1) motorized rifle platoon, (2) engineer detachment, (3) chemical defense element, (4) anti-aircraft defense elements, (5) a battery of self propelled artillery. The company simulated in the firing test consisted of tanks alone. The formation was arranged with two platoons up and one back simulating an assault posture. The tanks were not maneuvered during the firing test and the formation was essentially a "snapshot: of the company at a single point in time" (See Figure 6).

IV. The Target Tanks

The most effective targets available in sufficient numbers to simulate Soviet T-55 and T-62 tanks were US M-47 tanks. Both of the Soviet tank models are similar in armor

protection to the M-47. With the appropriate purging of the gasoline fuel system of the US tanks, the CDAT managed to field a target similar also in survivability to the T-55 and T-62 tanks from the viewpoint of ignitable internal material. The Soviet T-64 and later model tanks are ill-understood from the viewpoints of armor protection and the arrangement of internal components. The decision was made, accordingly, to simulate the better defined earlier model Soviet Tanks.

The M-47 tanks used in the firing test, although generally similar in survivability to Soviet T-55 and T-62 tanks, can be contrasted as follows. The rear surfaces of the US and Soviet tanks are significantly different, with the most important contrast being the large overhang on the US vehicle. The overhang in combination with the attacked stowage box and the lack of ammunition in the turret would seem to make the M-47 tanks particularly invulnerable to K-Kills associated with perforations through the rear of the turret. First, the rear of the US turret is difficult to perforate because of the heavy gauge steel stowage box and second, perforating projectiles and spall must traverse several feet of inert components before contacting either crew members or stowed ammunition.

Test data tend to support the above analysis, showing, for example that no K-Kill was inflicted by projectiles impacting from a rear aspect. In contrast, the Soviet T-55 and T-62 tanks have no overhang and carry ammunition in ready racks at the rear of the turrets. The M-47 tank has no special features at the sides of the turrets and hulls, which are similar to the turret overhang, and, because of slightly thinner armor on the side of the hull and a less efficiently shaped turret at the sides, would have to be acknowledged as slightly more vulnerable to perforation by kinetic energy projectiles.

The M-47 tanks used for targets were in excellent condition from the viewpoint of damage assessment. The exterior mobility components were complete. The interior components were less complete but included all of the most essential items, e.g., main gun, engine, transmission, fuel tanks, ammunition racks, etc. Other items such as oil coolers, range finders, vision devices, and radios, were not present in all tanks.

The most sensitive internal items from the viewpoint of catastrophic kills and M and F kill assessments are the following, which were placed in the test tanks as noted:

<u>Generic Sensitive Item</u>	<u>Test Item</u>
1. Ammunition-----	US Cartridge, 90mm TP-T
2. Fuel-----	Number 2 Diesel
3. Oil-----	Oil in Engine, Transmission and Drive Components
4. Personnel-----	Articulated Plywood Manikins

The tanks were static during the test and their engines were not running, with the result that the fuel and oil were much cooler and more inert than would have been and the case with a static vehicle with its engine running or a maneuvering tank. The kill ratios achieved in the firing test of 10 March therefore, are probably conservative from the viewpoint of fires resulting from ignited fuel and oil.

V. The Test and Results

The test itself consisted of bringing together the ammunition (Figure 2), gun (Figure 3), aircraft (Figure 4), and combat configured target tanks (Figure 5/Table I) into a realistic target array (Figure 6) for the purpose of simulating several minutes of air-to-ground combat.

The pilots flew two ship, combat tactics remaining below 300 feet altitude and pressed their attacks at low dive angles simulating operations below the altitudes for acquisition and tracking by an opposing air defense system during the entire attack. The attack was compressed into a time span of 4 minutes, 12 seconds in recognition of survivability considerations and time constraints involved in the successful attack of a fleeting target. Additional realism was obtained by permitting the pilots to deviate approximately 45° to the right and left of a "run-in" line on a heading of 45° magnetic established for safety purposes (Figure 6).

In this mission the pilots experimented initially with somewhat different attack tactics. There was some thought that a long burst combined with a sight alignment on two or more targets could provide a bonus effect by yielding a multi-kill capability per pass because of the overspray of projectiles in the target area. The target array (Figure 6) provided opportunities for test of the theory.

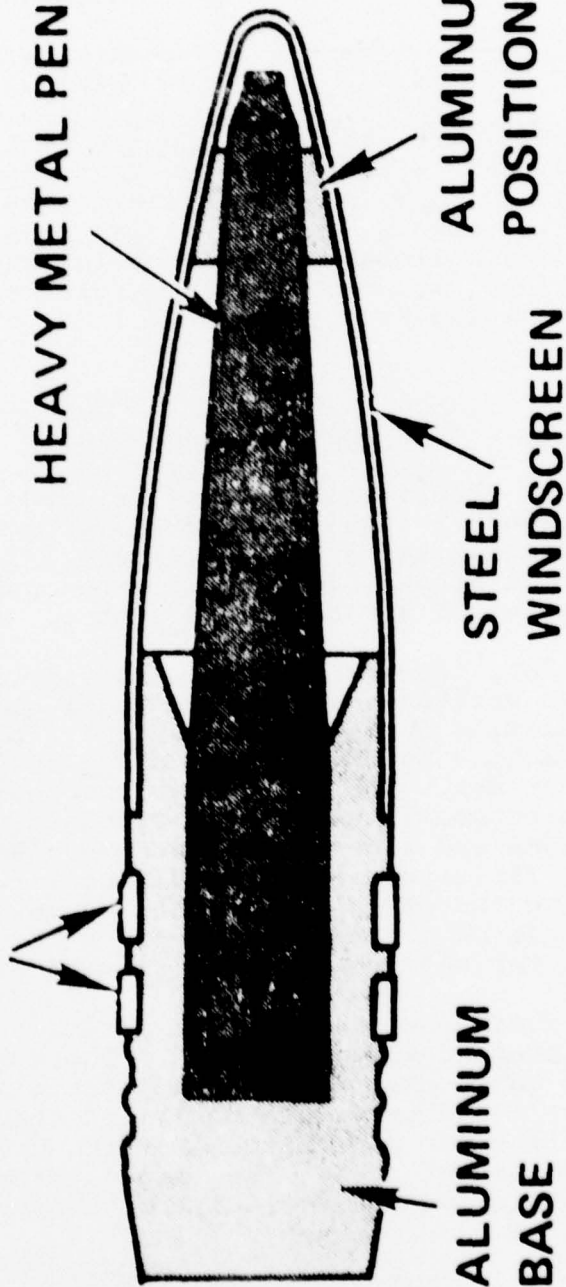
GAU-8/A AMMUNITION

API
PGU-14B

Cartridge Weight	1.55 lb.
Projectile Weight	.868 lb.
Fuze Weight	-
HE Weight	-
Case Weight	.333 lb.
Propellant Weight	.340 lb.
Cartridge Length	11.416 in. (max.)
Case Length	6.811 in. (max.)
Muzzle Velocity	3325 ft/sec

PLASTIC ROTATING BANDS

HEAVY METAL PENETRATOR



ARMOR PIERCING INCENDIARY (API)

Figure 2. -- GAU-8 30mm API Ammunition: Projectile Sketch and Round Characteristics

GAU-8/A GUN SYSTEM

Gun	7-Barrel Gatling
Weight (total)	4029 lbs.
Length (overall)	239 inches
Firing Rate	2100/4200 SPM
Ammunition Capacity	1350 rounds
Feed System	Double Ended Linkless
Drive System	Dual Hydraulic Motors
Power Requirements	77 hp
Dispersion - 80% (diameter)	5 milliradians
Average Recoil Force (at 4200 SPM)	10,000 lbs.
Design Burst Length	Ten 2-second bursts with one minute cool time between bursts

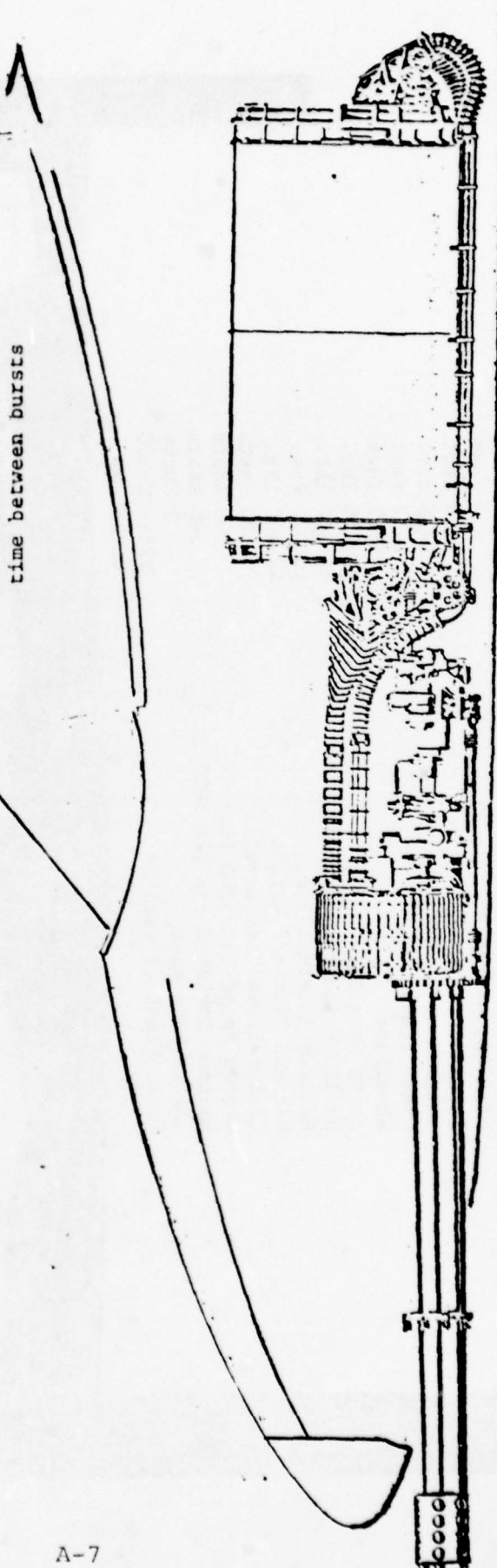


Figure 3. -- CHARACTERISTICS OF THE GAU-8/A 30MM GUN

Wing Span	57.5 feet
Wing Area	506.0 square feet
Wing Chord at Root	9.9 feet
Wing Aspect Ratio	6.5 feet
Length	53.3 feet
Height	14.6 feet
Wheel Track	17.2 feet
Wheelbase	17.7 feet
Empty Weight	20,246 lbs.
Design Weight (equipped)	30,700 lbs.
Maximum Internal Fuel	10,470 lbs.
Maximum Take-off Weight	47,400 lbs.
Cruise Speed (Sea Level)	300 knots
Cruise Speed (at 5000 ft.)	342 knots
Maximum Combat Speed (at 5000 ft.)	390 knots
Loiter Endurance	2 hours
Power Plant (2 each)	TF34-GE-100
	Turbofans

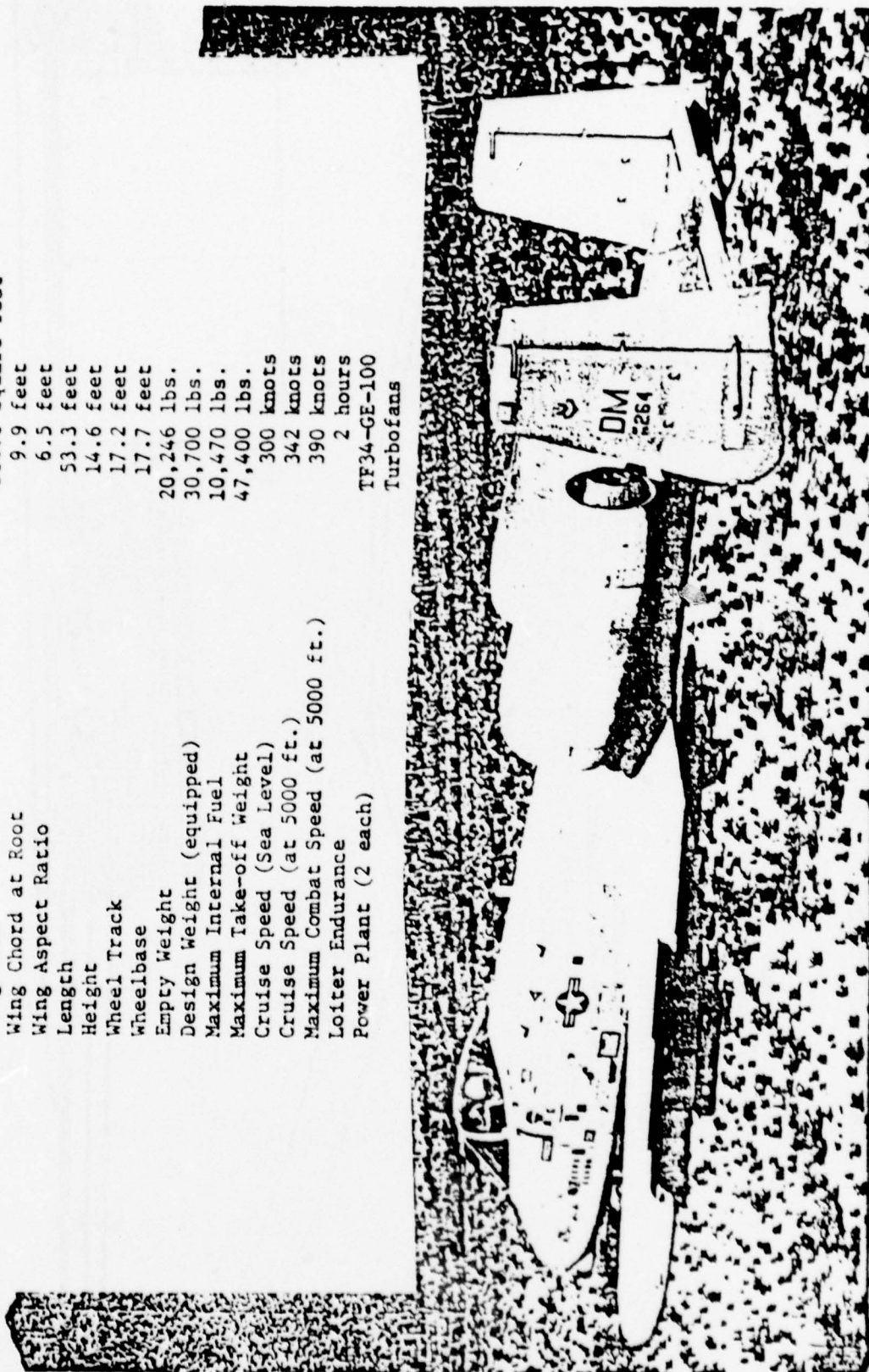


Figure 4. -- CHARACTERISTICS OF THE A-10A/GAU-8/A WEAPON SYSTEM

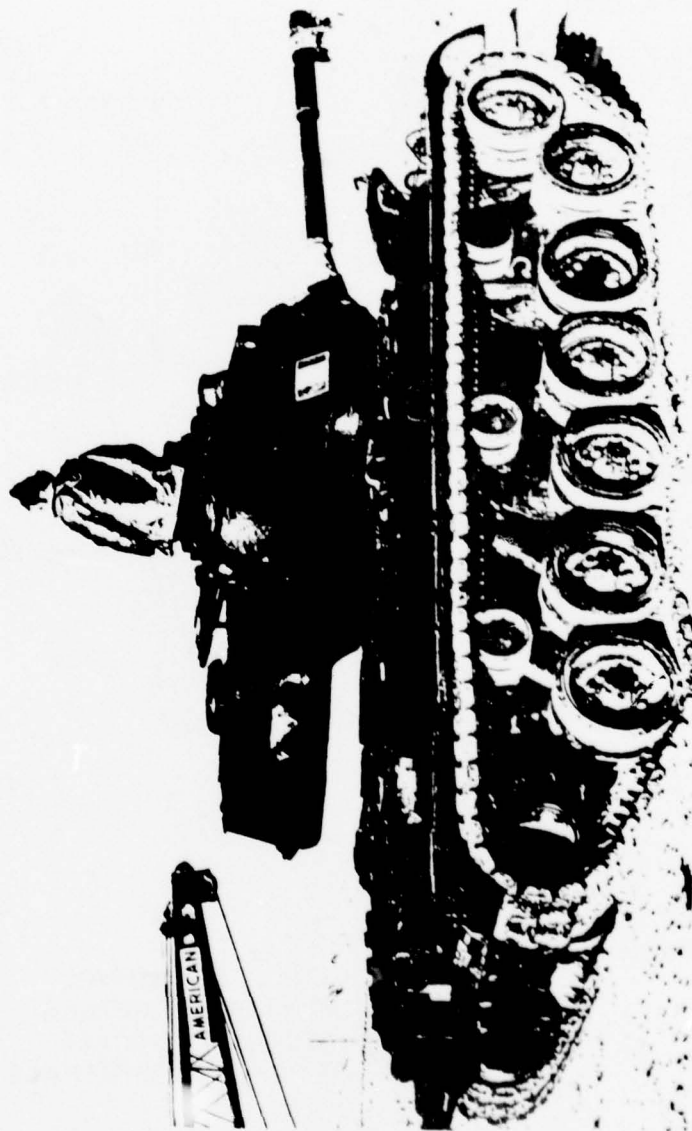
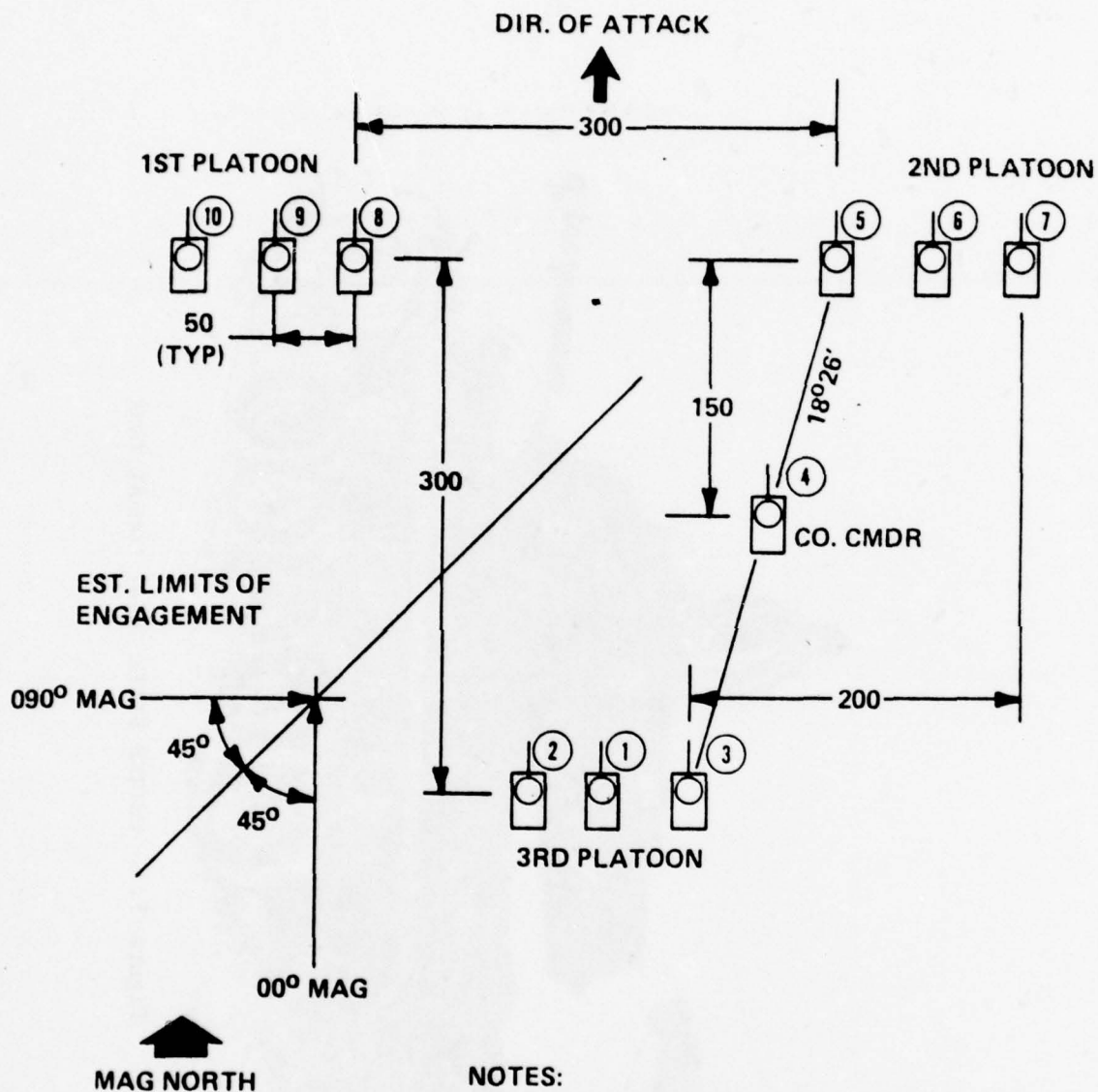
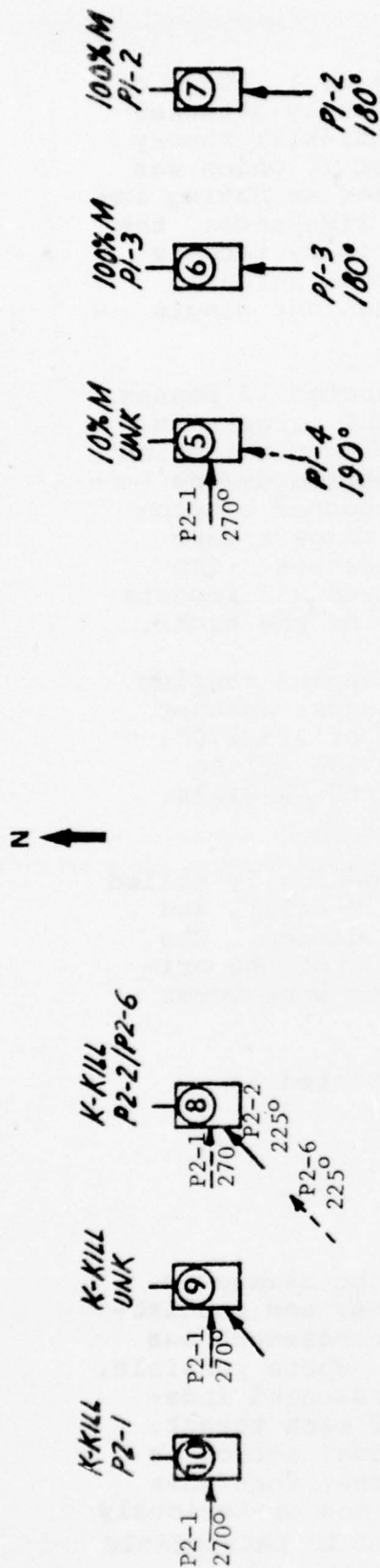


Figure 5. -- UNITED STATES M-47 COMBAT TANK

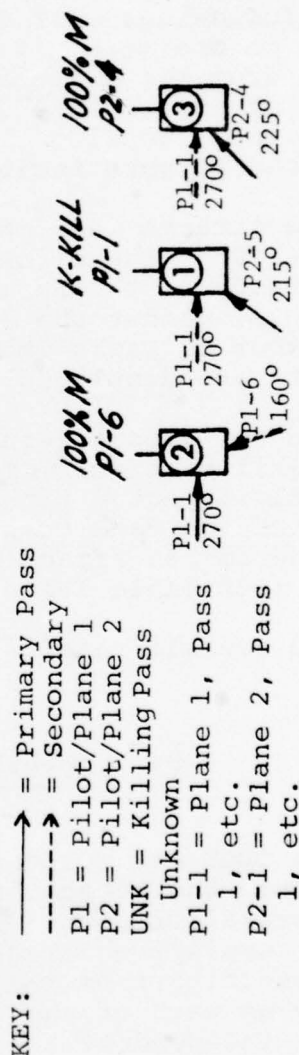
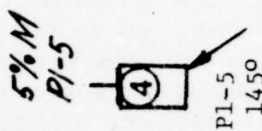


NOTES:
 OVERALL TGT ARRAY 500m X 300m
 DIMENSIONS IN METERS
 SKETCH NOT TO SCALE
 NOS REFER TO NUMERALS PAINTED ON TANK

Figure 6. -- A-10 COMBAT LETHALITY TARGET ARRAY
 10 MARCH 1978



NOTE: The pilots were restricted in their attacks to a sector of 90-270° magnetic, hence, the concentration of attacks in that 180° sector.



KEY:
 → = Primary Pass
 ---→ = Secondary
 P1 = Pilot/Plane 1
 P2 = Pilot/Plane 2
 UNK = Killing Pass
 Unknown
 P1-1 = Plane 1, Pass 1, etc.
 P2-1 = Plane 2, Pass 1, etc.

Figure 7 - - Primary, Secondary or Incidental, and Unidentified Passes

Pilot P1, accordingly, attacked targets 2, 1, and 3 on his first pass, and pilot P2 almost simultaneously attacked targets 10, 9, and 8 (See Figure 7). The multi-kill theory did not prove out. Only in the case of target 1, which was a K-Kill, was the killing projectile identified as having impacted a secondary target. In the remaining five cases, the most damaging impacts were associated with primary targets in four instances and no specific target in one instance. The pilots subsequently reverted to attacks against single targets.

In the mission overall, the pilots conducted 12 passes, which resulted in impacts against 20 individual targets in the 10-tank array. The single and multiple target situation was the following: (1) four targets were impacted by one aircraft on one pass, (2) two targets were impacted by projectiles from two different passes, (3) four targets were impacted by projectiles from three different passes. The pilots fired a total of 1684 rounds and achieved 253 impacts against the targets including 43 perforations of the armor.

The attacks were made at attack aspect angles ranging from 145-270°. The pilots made 55% of the attacks against the left side of the targets at aspect angles of 225-270°. The attacks against the left side resulted in 63% of the total number of tanks immobilized and 100% of the K-Kills. These data are displayed in Tables II and III.

The air attack resulted in four catastrophically killed tanks (K-Kills), four immobilized tanks (100% M-Kill), and two lightly impacted tanks with mobility type damage. The strength of the tank company was reduced to 20% of the original, and combat effectiveness as a company to some lower figure. (See Table IV).

The overall results of the test are presented in Table V.

VI. COMBAT DAMAGE ASSESSMENT

The CDAT was responsible for assessing the damage resulting from the attack, assigning kill factors, and publishing the overall report. The damage and kill assessment was based on cumulative damage from all attacks. Where possible, damage resulting from individual attacks was assessed independently as part of the overall evaluation of each target. Where the independent assessment of an individual attack is made, the assessment is presented with the caveat that when earlier attacks did not result in crew casualties or seriously degrade mobility, the posture of tanks on a dynamic battlefield might change with possible differences in results.

<u>ATTACK ASPECT ANGLE</u>	<u>NO. TARGETS IMPACTED</u>	<u>ROUNDS FIRED</u>	<u>IMPACTS</u>	<u>PERFS</u>
145-180° (RT REAR)	4 (20%)	695 (41%)	66 (26%)	8 (19%)
190-215° (LFT REAR)	2 (10%)	213 (13%)	12 (5%)	0 (0%)
225-270° (LFT SIDE)	11 (55%)	776 (46%)	160 (63%)	32 (74%)
UNKNOWN	3 (15%)	- -	15 (6%)	3 (7%)
TOTALS	20 (100%)	1684 (100%)	253 (100%)	43 (100%)

TABLE II. ROUNDS FIRED, IMPACTS, AND PERFORATIONS AS A FUNCTION OF ATTACK ASPECT ANGLE (10 MAR 78)

ATTACK ASPECT ANGLE	KILLING PASS	TANK TARGET IMPACTED	KILL ASSESMENT		
			M	F	K
270°	P1-1	1	-	-	100%
270°	P2-4	10	-	-	100%
230-270°	UNK	9	-	-	100%
225°	P2-2/P2-6	8	-	-	100%
225°	P2-4	3	100%	40%	-
190-270°	UNK	5	10%	-	-
180°	P1-3	6	100%	-	-
180°	P1-2	7	100%	-	-
160°	P1-6	2	100%	95%	-
145°	P1-5	4	5%	-	-

DISCUSSION: The table shows that the four catastrophic kills were at attack aspects of 225-270° representing predominately side surfaces of the tanks. High percentage mobility kills predominated, in contrast, at attack aspects of 145°-190°, which represent largely rear surfaces of the tanks.

TABLE III. A-10/GAU-8 EFFECTIVENESS IN COMBAT
VS SIMULATED SOVIET TANK COMPANY
AS A FUNCTION OF ATTACK ASPECT ANGLE
(10 MAR 78)

TYPE OF KILLING
DAMAGE

RATIOS
(KILLS/PASS)

TANKS IMMOBILIZED*
A-10 PASSES

$$= \frac{8}{12} = 0.67$$

TANKS CATASTROPHICALLY KILLED
A-10 PASSES

$$= \frac{4}{12} = 0.33$$

*IMMOBILIZED TANKS = 100% M-KILLS AND K-KILLS

TABLE IV. A-10/GAU-8 EFFECTIVENESS IN SIMULATED
COMBAT VS SIMULATED SOVIET TANK COMPANY,
RATIOS OF KILLS PER PASS (10 MAR 78)

<u>TABULATED DATA</u>	<u>NUMBER AND/OR PERCENT</u>
Number of Passes	12
Number of Impacted	20
Total Rounds Fired	1684
Total Impacts on Targets	253 (15%)
Total Perforations Through Armor	43 (17%)
K-Kills Per Pass	33%
M-Kills Per Pass	33%
Tanks Immobilized Per Pass (i.e., 100% M and K Kills Per Pass)	67%

TABLE V. TABULATED SUMMARY OF DATA FOR A-10/GAU-8
FIRINGS OF 10 MAR 78

Some targets were assessed as catastrophically destroyed even though direct observation showed a delay between the attack and the burning or explosion of the vehicle. Such an assessment was made on the basis of evidence of simultaneous crew casualties which made it highly improbable that the crew would have any capability to resist the propagation of small fires into killing fires and explosions.

The assessment of weapon effects and the assignment of kill values is discussed below. Each target is examined individually in an identical format which includes a description of the attacks/passes; the number of impacts resulting in perforations, significant damage and insignificant damage; a multiple pass/attack assessment where possible; and the rationale behind the overall assessment. The examination comprises a brief single page description of each pass and the weapon effects and damage resulting from it. Each examination sheet is followed by one or more photographs which illustrate the more significant weapon effects and/or damage on the target tank. Perforations, damaging hits in exterior suspension components, and impacts on crew mannikins are typically shown in the photographs.

Tank Target Damage Summary

M-47 Tank Number 1

1. Description: Attacked during passes P1-1, P2-5, and one unidentified pass. Kill attributed to P1-1.
2. Kill Assessment: 100% K-Kill resulting from the following effects:
 - a. Perforations: 7
 - b. Significant Damage: Omitted - Catastrophic fire and explosion overrides other damage.
 - c. Insignificant Damage: Omitted - Catastrophic fire and explosion overrides other damage.
3. Multiple Pass Assessment: Not possible
4. Rationale for Kill Assessment: 100% K-Kill due to a fuel fire resulting from Impact 25 (Figure 8) which could not be extinguished by the crew because of casualties inflicted by Impacts 5 and 6 (Figure 9), and 16 (Figure 10).



FIGURE 8 - TARGET 1
IMPACT 25, PERFORATION OF LEFT HULL AND PENETRATION INTO LEFT
FUEL TANK

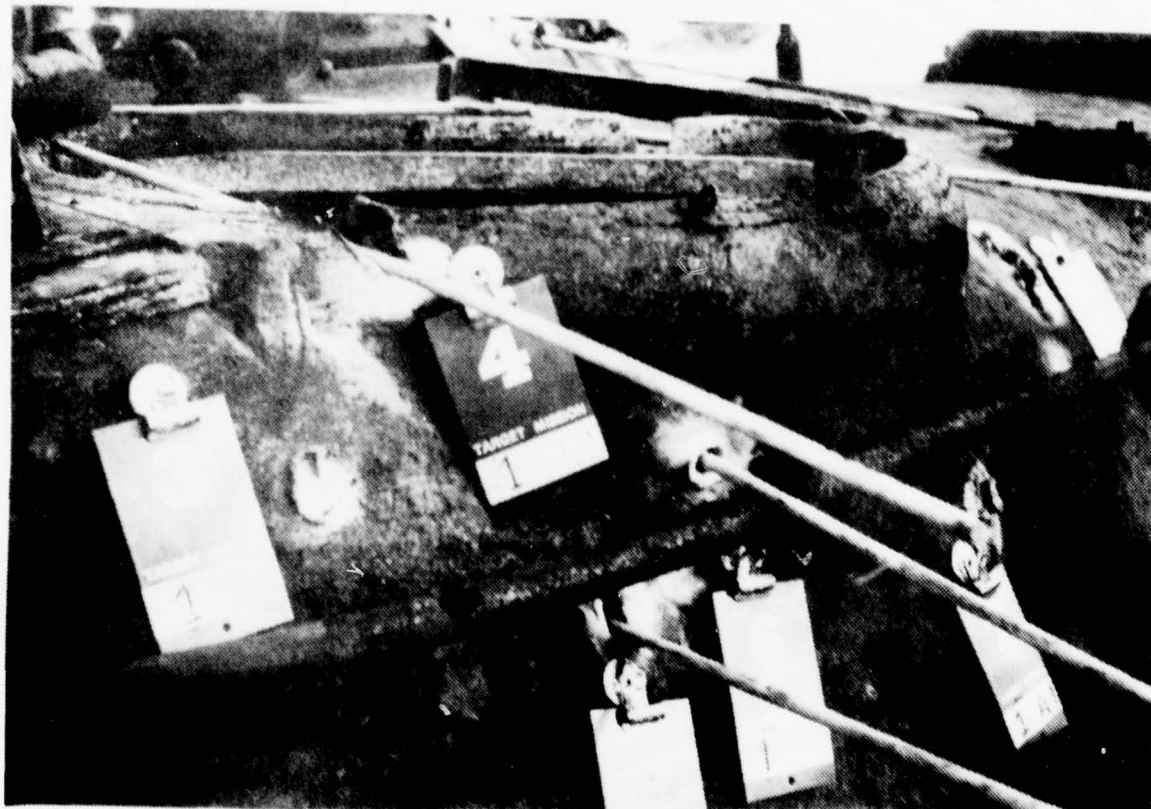


FIGURE 9 - TARGET 1
IMPACTS 5 and 6, PERFORATIONS OF LEFT TURRET INTO FIGHTING
COMPARTMENT

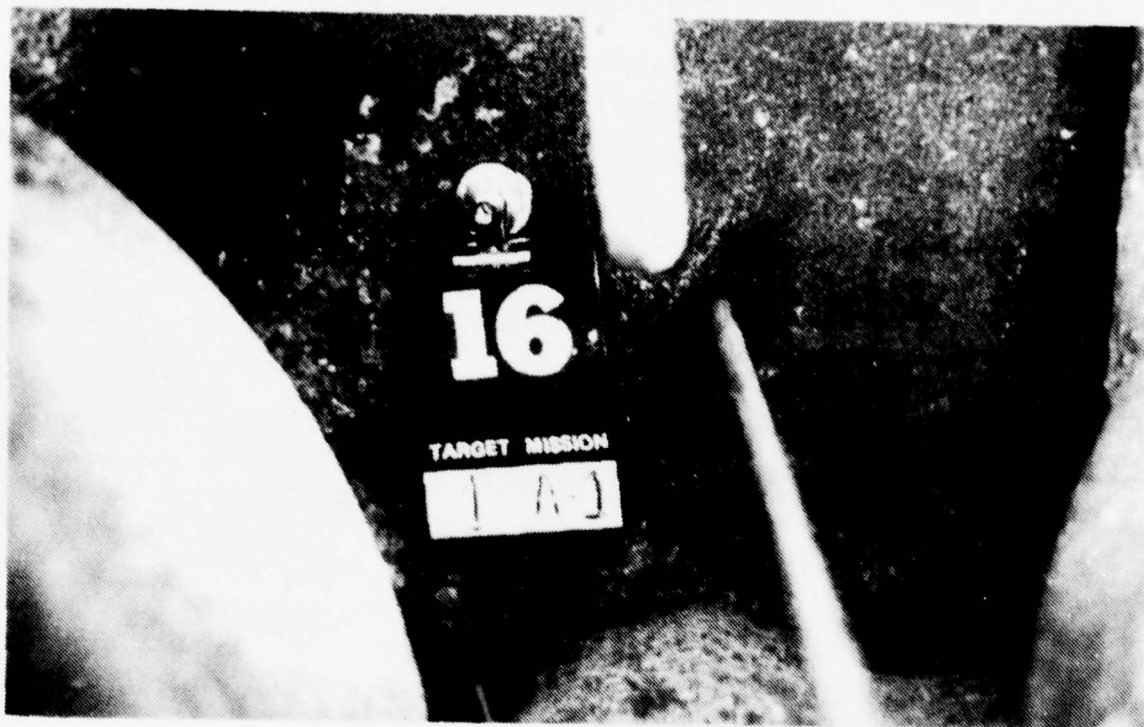


FIGURE 10 - TARGET 1
IMPACT 16, PERFORATION OF LEFT HULL INTO DRIVER'S COMPARTMENT

Tank Target Damage Summary

M-47 Tank Number 2

1. Description: Attacked during passes Pl-1 and Pl-6
Kill attributed to Pl-6.

2. Kill Assessment: 100% M-Kill, 95% F-Kill resulting
from the following effects:

- a. Perforation: 7
- b. Significant Damage: 8
- c. Insignificant Damage: 12

3. Multiple Pass Assessment:

PASS Pl-1

M - Kill: None

F - Kill: 20% (Based on
penetrations thru gun tube)

PASS Pl-6

M - Kill: 100% (Based on
penetrations into transmis-
sion case)

F - Kill: 95% (Based on
"sole survivor" criterion
for crew casualties)

4. Rationale for Kill Assessment:

- a. M-Kill: 100% M-Kill due to transmission damage
resulting from Impacts 16 and 18 (Figure 11)
- b. F-Kill: 95% F-Kill due to crew casualties (sole
survivor criteria) inflicted by Impacts 1 and 3
(Figure 12) and to Impacts 4 and 5 (Figure 13)
which penetrated the gun tube.

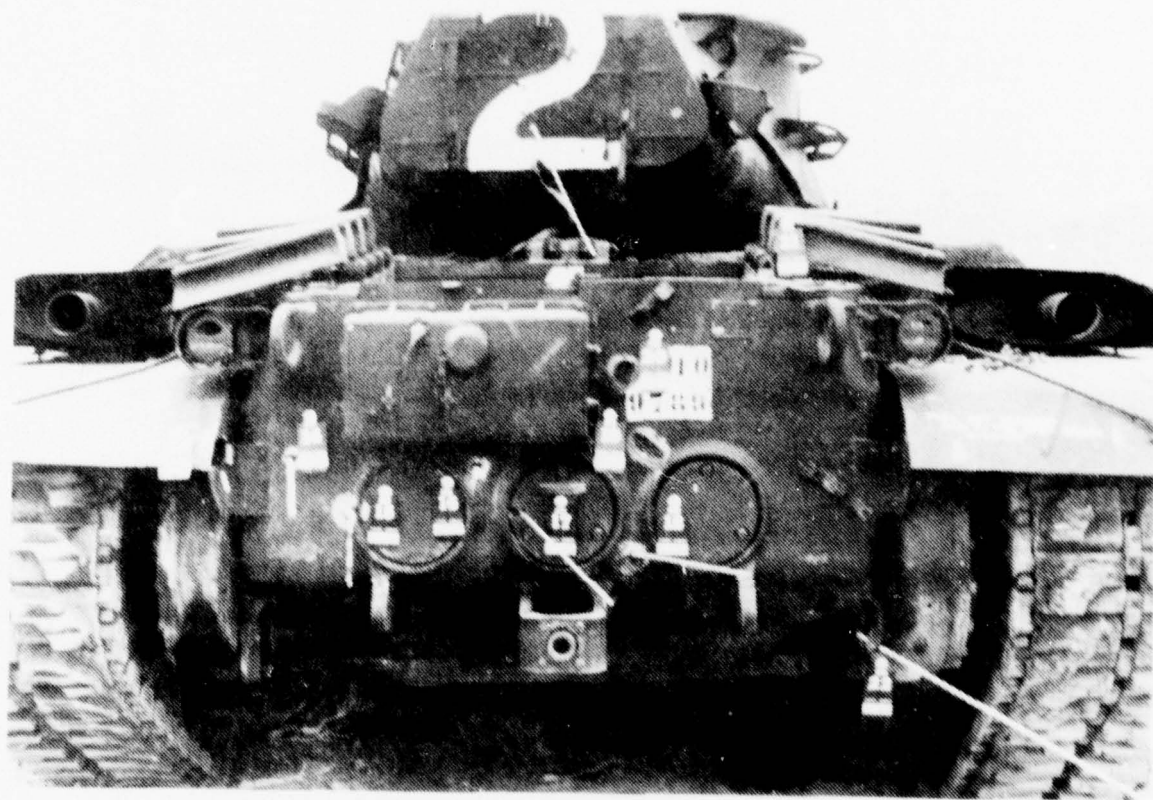


FIGURE 11 - TARGET 2
IMPACTS 14, 15, 16 and 18, PERFORATIONS OF REAR HULL INTO
ENGINE COMPARTMENT

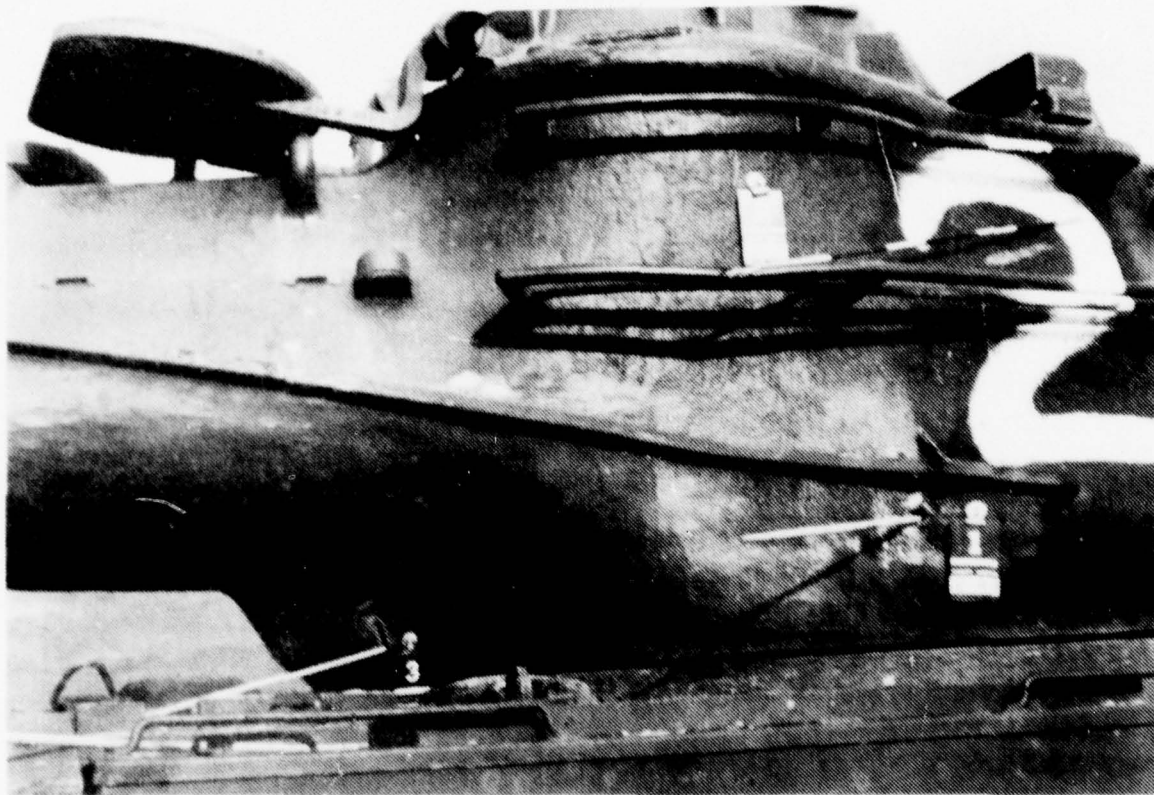


FIGURE 12- TARGET 2
IMPACTS 1 and 3, PERFORATIONS OF RIGHT TURRET INTO FIGHTING
COMPARTMENT

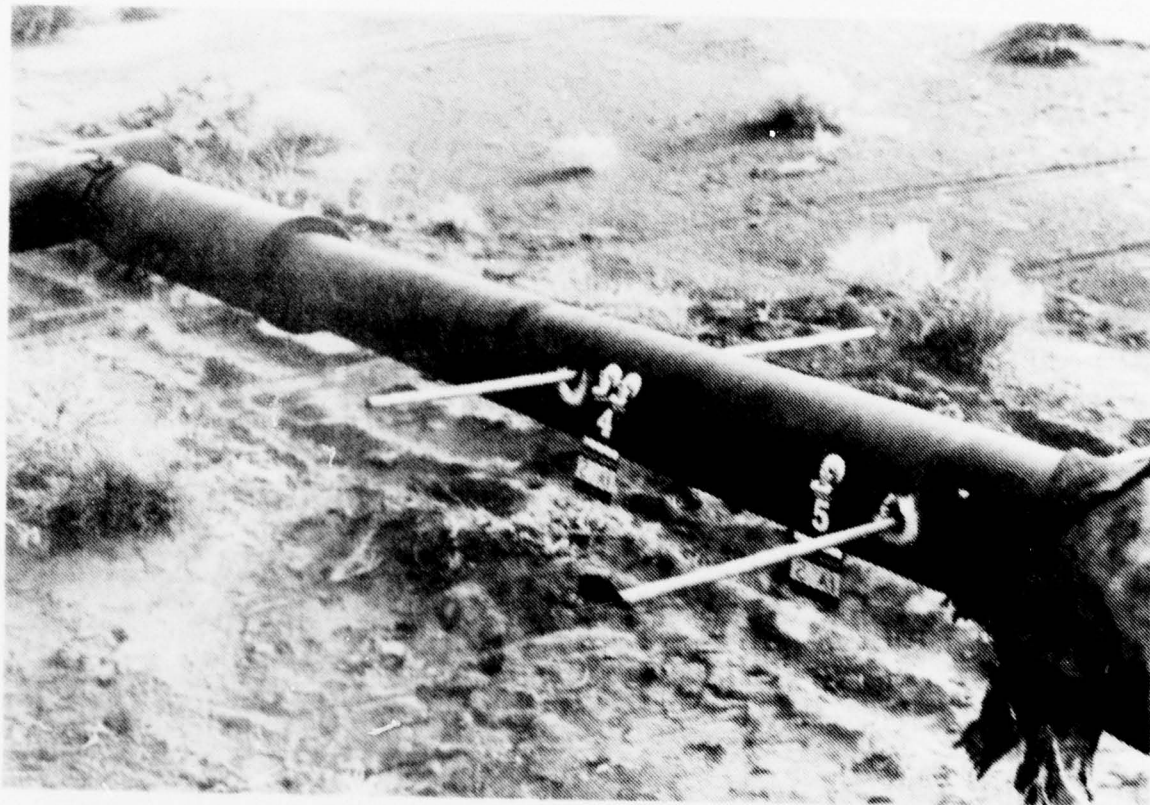


FIGURE 13 - TARGET 2
IMPACTS 4 and 5, PENETRATIONS THROUGH GUN TUBE

Tank Target Damage Summary

M-47 Tank Number 3

1. Description: Attacked during passes P1-1, P2-4, and one unidentified pass. Kill attributed to P2-4.
2. Kill Assessment: 100% M-Kill, 40% F-Kill resulting from the following effects:
 - a. Perforations: 4
 - b. Significant Damage: 7
 - d. Insignificant Damage: 13
3. Multiple Pass Assessment:

PASS P1-1

M - Kill: None

F - Kill: 20% (Based on possible loss of power and gun elevation and traverse, and a perforation thru the gun tube)

PASS P2-4

M - Kill: 100% (Based on damage to the track adjusting idler wheel)

F - Kill: 20% (Based on casualty criteria associated with loss of the driver)

4. Rationale for Kill Assessment:
 - a. M-Kill: 100% M-Kill due to track adjusting idler wheel damage resulting from Impact 5 (Figure 14) driver casualty inflicted by Impact 7 (Figure 15).
 - b. F-Kill: 40% F-Kill based on driver casualty criteria, possible loss of power elevation and traverse, and penetration through the gun tube.

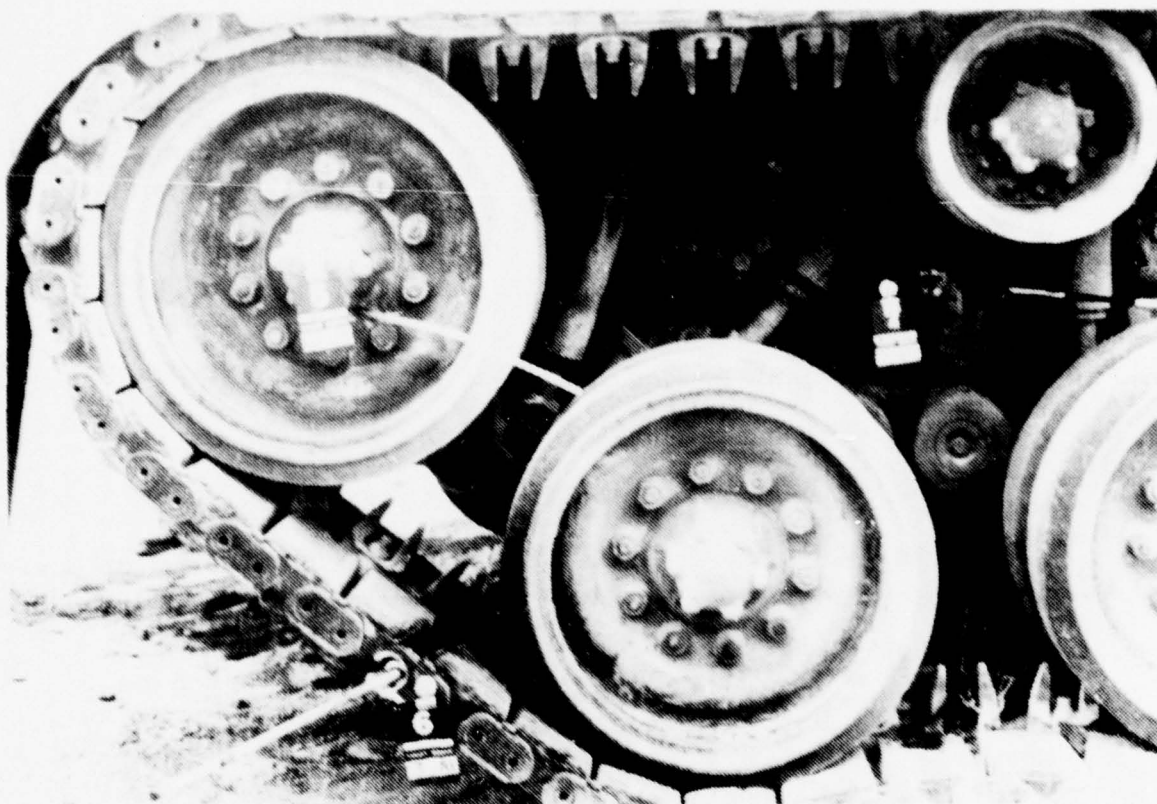


FIGURE 14 - TARGET 3
IMPACT 7, PERFORATION OF LEFT HULL INTO DRIVER'S COMPARTMENT
AND IMPACT 5, PENETRATION OF LEFT IDLER WHEEL HUB

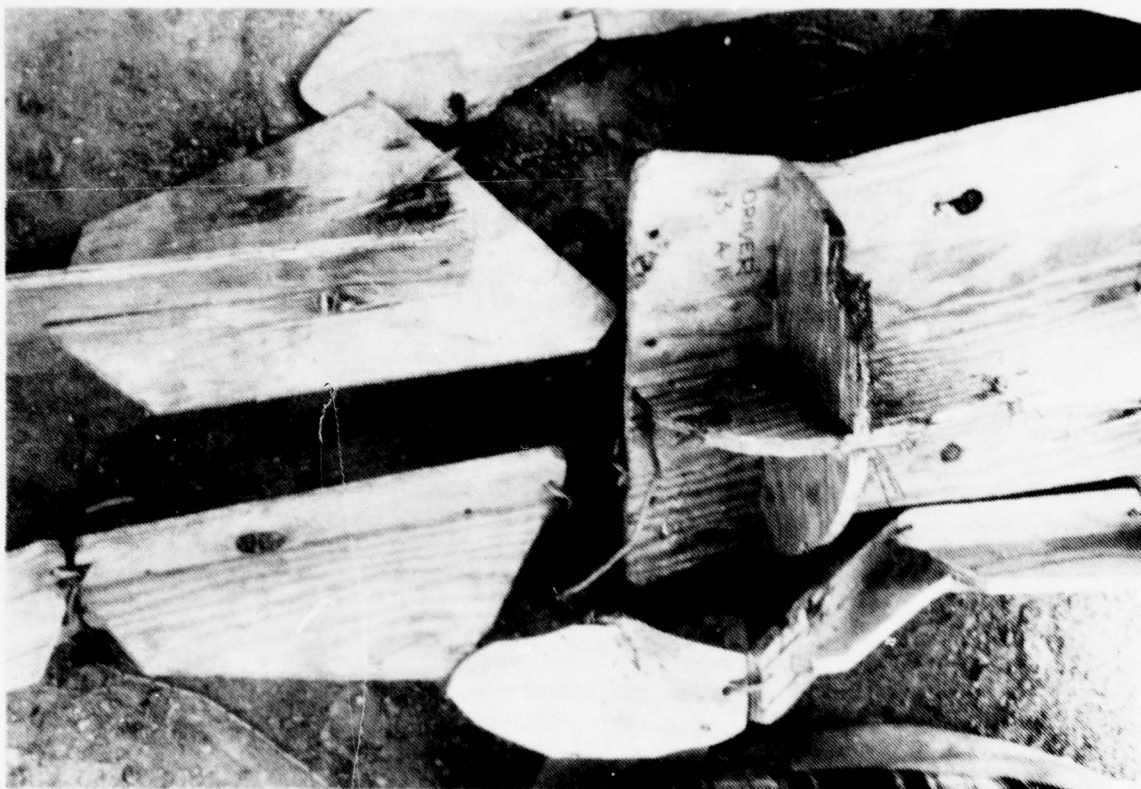


FIGURE 15 - TARGET 3
DAMAGE TO MANNIKIN AT DRIVER'S
STATION CAUSED BY IMPACT NO. 7

Tank Target Damage Summary

M-47 Tank Number 4

1. Description: Attacked during pass Pl-5 only.
2. Kill Assessment: 5% M-Kill resulting from the following effects:
 - a. Perforations: 0
 - b. Significant Damage: 3
 - c. Insignificant Damage: 9
3. Multiple Pass Assessment: N/A
4. Rationale for Kill Assessment: Light damage to 2 road-wheels, 2 shock absorbers, and 1 track center guide by Impacts 7, 8, and 11. Most severe damage indicated by Impact 11 (Figure 16).

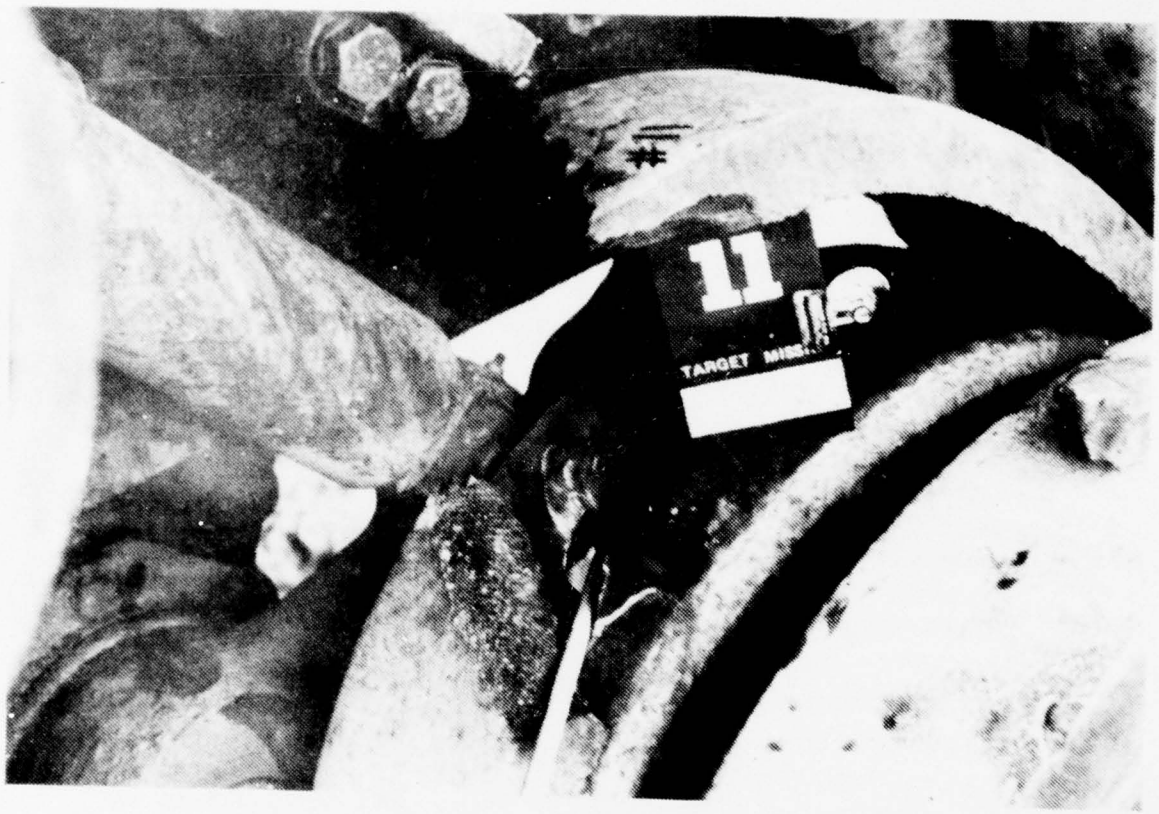


FIGURE 16 - TARGET 4
IMPACT 11, DAMAGE TO RIGHT NO. 1 ROAD WHEEL

Tank Target Damage Summary

M-47 Tank Number 5

1. Description: Attacked during passes P2-1 and P1-4.
Damage divided approximately equal between passes.
2. Kill Assessment: 10% M-Kill resulting from the following effects:
 - a. Perforations: 0
 - b. Significant Damage: 4
 - c. Insignificant Damage: 7
3. Multiple Pass Assessment:

<u>PASS P2-1</u>	<u>PASS P1-4</u>
M - Kill: 5% (Associated with damage resulting from impacts 5, 7 and 8)	M - Kill: 5% (Associated with damage resulting from impact 11)
F - Kill: None	F - Kill: None
4. Rationale for Kill Assessment: Cumulative (5% each pass) damage to track support roller, 2 center guides, 3 tank shoes, 1 end connector, and 1 drive sprocket by Impacts 5, 7, 8, and 11. Most severe damage indicated by Impact 11 (Figure 17).



FIGURE 17 - TARGET 5
IMPACT 11, DAMAGED TRACK SHOES, END CONNECTOR AND
DRIVE SPROCKET

Tank Target Damage Summary

M-47 Tank Number 6

1. Description: Attacked during pass Pl-3 only.
2. Kill Assessment: 100% M-Kill resulting from the following effects:
 - a. Perforations: 1
 - b. Significant Damage: 4
 - c. Insignificant Damage: 8
3. Multiple Pass Assessment: N/A
4. Rationale for Kill Assessment: 100% M-Kill due to perforated transmission oil cooler inlet and outlet lines resulting from Impact 9 (Figure 18).



FIGURE 18 - TARGET 6
IMPACT 9, SPALL FRAGMENT PENETRATIONS INTO
TRANSMISSION OIL COOLER INLET AND OUTLET LINES

Tank Target Damage Summary

M-47 Tank Number 7

1. Description: Attacked during Pl-2 only.
2. Kill Assessment: 100% M-Kill resulting from the following effects:
 - a. Perforations: 1
 - b. Significant Damage: 7
 - c. Insignificant Damage: 16
3. Multiple Pass Assessment: N/A
4. Rationale for Kill Assessment: 100% M-Kill due to severed transmission shifting control rod, severed engine oil cooler outlet line, and severed transmission oil cooler inlet and outlet lines resulting from Impact 19 (Figures 19 and 20).



FIGURE 19 - TARGET 7
IMPACT 19, PERFORATION INTO ENGINE COMPARTMENT

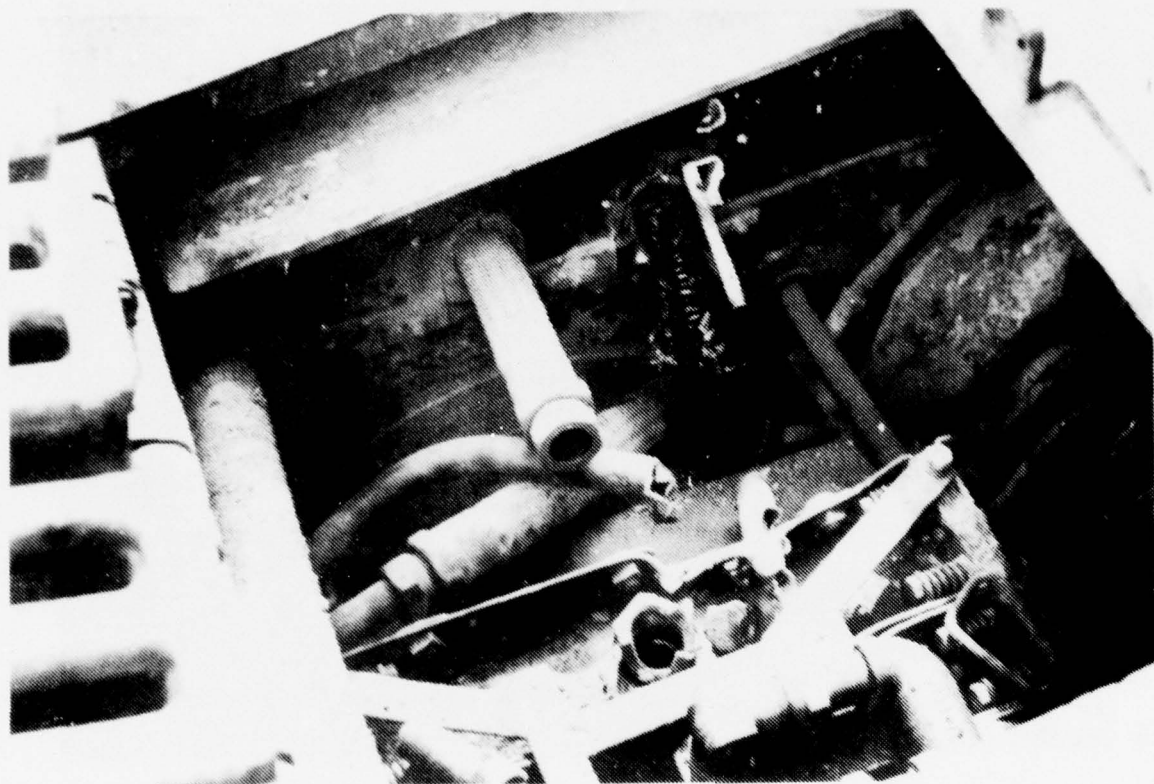


FIGURE 20 - TARGET 7
SEVERED OIL COOLER INLET AND OUTLET LINES, IMPACT NO. 19

Tank Target Damage Summary

M-47 Tank Number 8

1. Description: Attacked during passes P2-1, P2-2, and P2-6.
Kill attributed to passes P2-2 and P2-6.
2. Kill Assessment: 100% K-Kill resulting from the following effects:
 - a. Perforations: 3
 - b. Significant Damage: Omitted - Catastrophic fire and explosions overrides other damage.
 - c. Insignificant Damage: Omitted - Catastrophic fire and explosions overrides other damage.
3. Multiple Pass Assessment: Not Possible
4. Rationale for Kill Assessment: 100% K-Kill due to a fuel fire resulting from Impact 19 which could not be extinguished by the crew because of casualties inflicted by Impact 2.

Tank Target Damage Summary

M-47 Tank Number 9

1. Description: Attacked during passes P2-1, P2-3 and one unidentified pass. Kill could not be attributed to a specific pass.
2. Kill Assessment: 100% K-Kill resulting from the following effects:
 - a. Perforations: 9
 - b. Significant Damage: Omitted - Catastrophic fire and explosions override other damage.
 - c. Insignificant Damage: Omitted - Catastrophic fire and explosions override other damage.
3. Multiple Pass Assessment: Not Possible
4. Rationale for Kill Assessment: 100% K-Kill due to multiple perforations into the fighting compartment (2), driver's compartment (2), and hull (5), which caused at least 4 crew casualties, two penetrations into the left bulkhead ammunition stowage area, and one penetration into the left fuel tank (Figures 21, 22, and 23).



FIGURE 21 - TARGET 9
IMPACTS 5 AND 8, PERFORATIONS OF LEFT
TURRET INTO FIGHTING COMPARTMENT

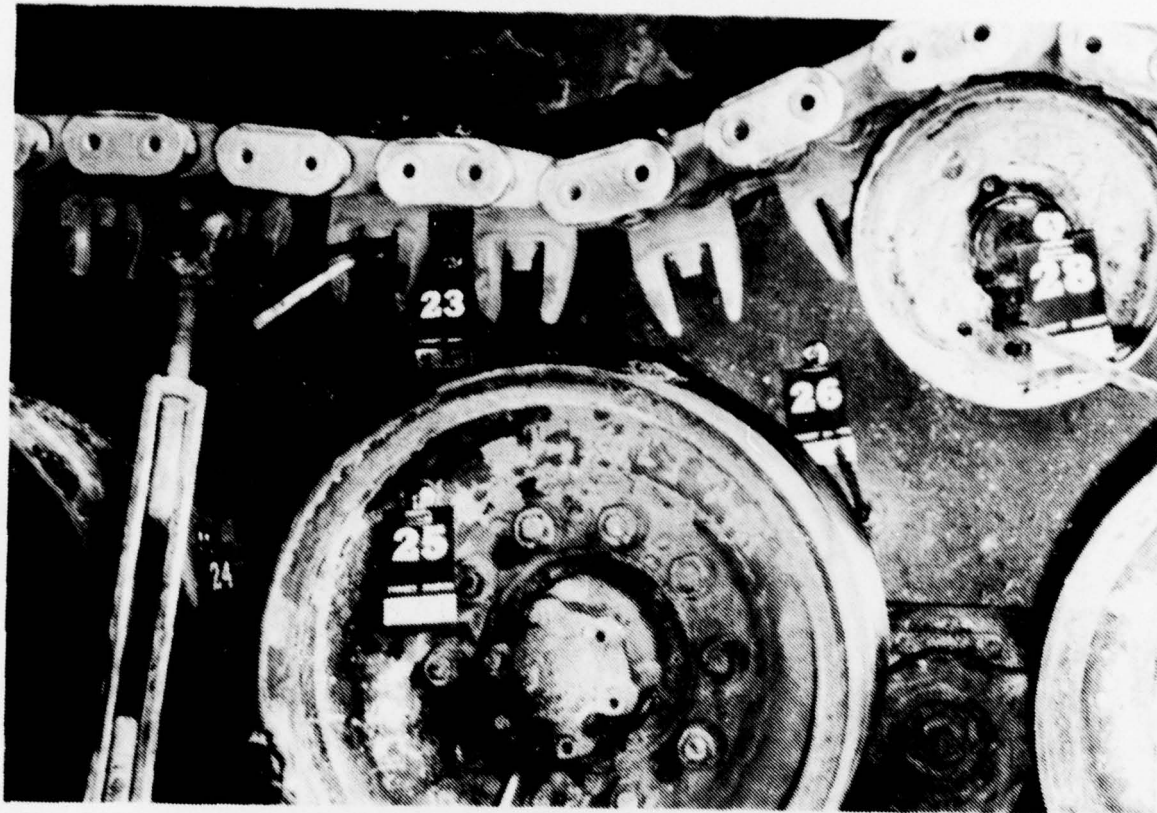


FIGURE 22 - TARGET 9
IMPACTS 23 AND 26, PERFORATIONS OF LEFT HULL INTO BULK-
HEAD AMMUNITION STOWAGE COMPARTMENT

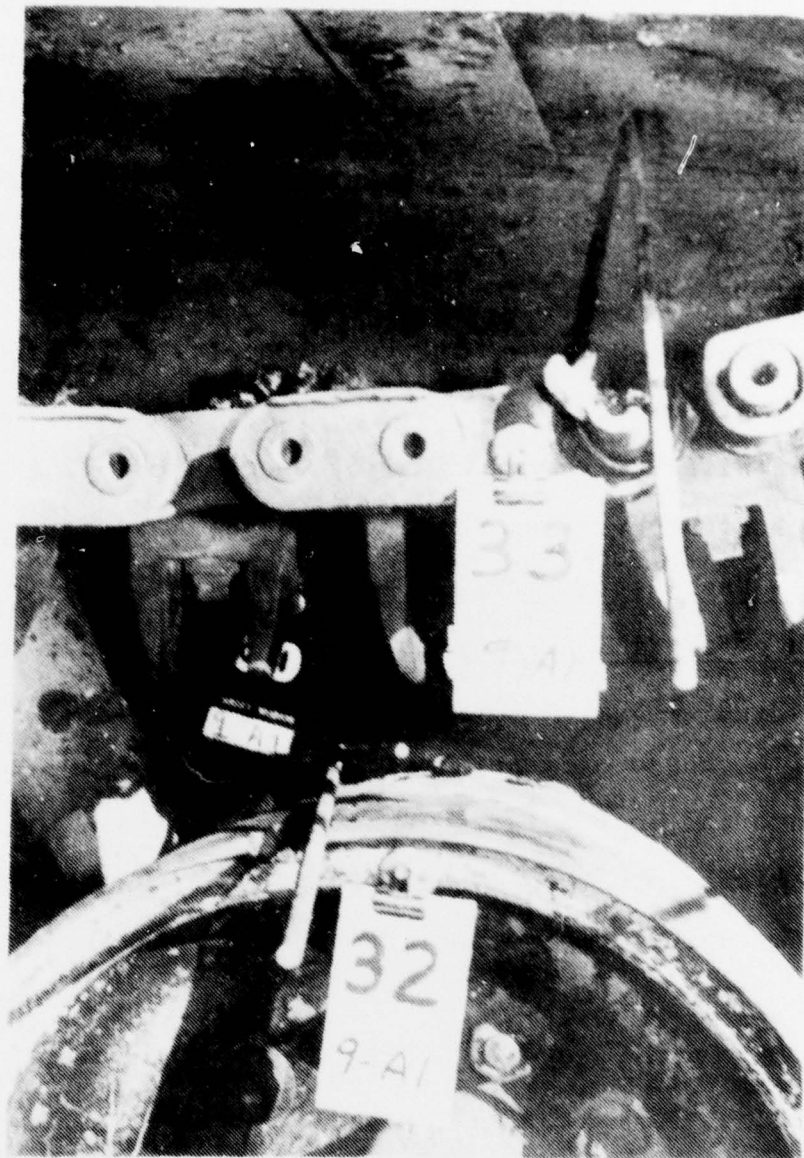


FIGURE 23 - TARGET 9
IMPACT 30, PERFORATION OF LEFT HULL
INTO LEFT FUEL TANK

Tank Target Damage Summary

M-47 Tank Number 10

1. Description: Attacked during pass P2-1 only.
2. Kill Assessment: 100% K-Kill resulting from the following effects.
 - a. Perforations: 11
 - b. Significant Damage: Omitted - Catastrophic fire and explosions overrides other damage.
 - c. Insignificant Damage: Omitted - Catastrophic fire and explosions overrides other damage.
3. Multiple Pass Assessment: N/A
4. Rationale for Kill Assessment: 100% K-Kill due to multiple perforations into the fighting compartment (4) and hull (7) which caused at least 3 crew casualties, one penetration into the left bulkhead ammunition stowage area, two penetrations into the left fuel tank, and three penetrations into the engine compartment (Figures 24 and 25).

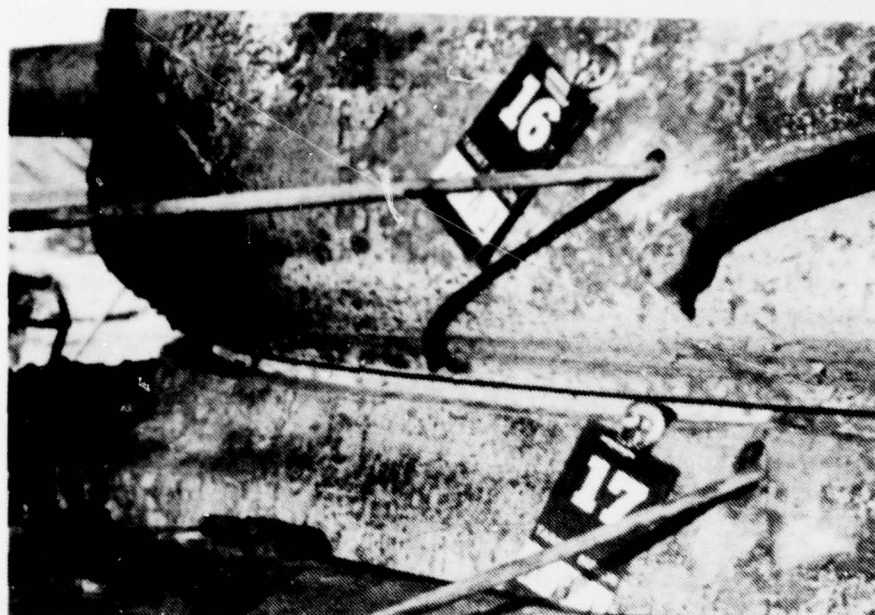


FIGURE 24 - TARGET 10
IMPACT 16, PERFORATION OF LEFT TURRET
INTO FIGHTING COMPARTMENT

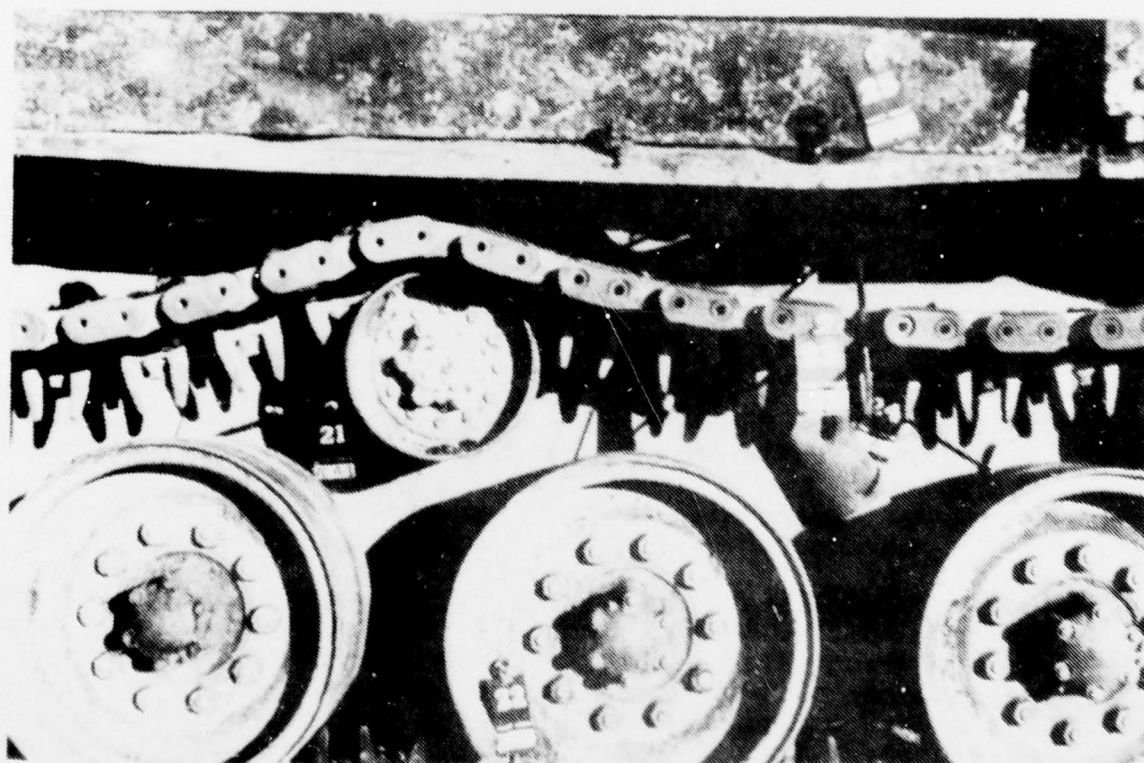


FIGURE 25 - TARGET 10
IMPACTS 24 AND 25, PERFORATIONS OF LEFT
HULL AND PENETRATIONS INTO THE LEFT FUEL TANK

VIII. Summary and Conclusions

Working within the framework of the Lot Acceptance verification Program (LAVP) of the Armaments Directorate, A-10 System Program Office, and on the basis of general cooperation between the USAF Systems and Tactical Air Commands, two pilots of the 66th Fighter Weapons Squadron, Nellis AFB, Nevada, attacked a simulated Soviet tank company with A-10/GAU-8 weapon systems on 10 March 1978. The Soviet tank company was simulated by 10 M-47 tanks, which were loaded with 90mm TP ammunition, diesel fuel, lubricating oil, and crew mannikins. The purpose of the test was to increase knowledge of the lethality of the GAU-8 30mm armor piercing ammunition when fired at low altitudes and dive angles by A-10 aircraft. The damage assessment technique used in the test was one of live firing against high fidelity, combat loaded MBTs with weapon effects and damage assessed on the basis of results obtained against actual main battle tanks. The data obtained are summarized generally in Table V.

The most numerous and effective attack aspect angle was 270° against the left sides of the target tanks, which accounted for 63% of the impacts, 74% of the perforations and 100% of the K-Kills, while comprising only about 50% of the firing passes. The superior lethality demonstrated by the passes which took place directly or predominately from a side aspect is in accordance with the following observed factors and largely explained by them:

- (1) Low horizontal obliquity angles, i.e. the projectiles are impacting at right angles to the side surfaces.
- (2) Armor thinner on the sides than at the front.
- (3) Low vertical obliquity angles, i.e., the vertical angles of attack on the side surfaces are the same as the low (1-7°) dive angles occasioned by the low altitude tactics of the pilots.
- (4) Ammunition stowed at sides of hulls.

The operational effectiveness of the A-10 under the conditions of the test can be approximated by the average number of Kills achieved per firing pass. Kills are described largely in terms of the damage inflicted with the most decisive damage being catastrophic (internal explosion and/or fire) and perhaps the next and most important being mobility type damage for modern motorized ground forces. The following averages were derived from the firing test, and, based on the empirical

and significantly unconstrained nature of the test, are valuable approximations of combat:

Catastrophic
Effectiveness

$$\frac{\text{K-Kills}}{\text{A-10 Passes}} = \frac{4}{12} = 0.33$$

100% M-Kill
Effectiveness

$$\frac{100\% \text{ M-Kills}}{\text{A-10 Passes}} = \frac{4}{12} = 0.33$$

Total Immobilization
Effectiveness

$$\frac{\text{K \& 100\% M- Kills}}{\text{A-10 Passes}} = \frac{8}{12} = 0.67$$

TAB A TO APPENDIX A
DEFINITIONS

The terms used in this report, are defined below:

IMPACT - Any evidence of a projectile strike against any portion of the target. Ground ricochets striking the target were classified as "impacts".

PERFORATION - Any rupture of the armored envelope caused by an impacting projectile which results in behind-the-plate effects by the projectile or spall fragments. A perforation can occur only when the armor is impacted. The word "Perforation" was deliberately selected to avoid the ambiguities which may occur through use of the word "penetration".

HIT - Any impact not classified as a perforation.

MOBILITY KILL (M-KILL) - Loss of tactical mobility resulting from damage which cannot be repaired by the crew on the battlefield. A tank is considered to have sustained an M-Kill when it is no longer capable of executing controlled movement on the battlefield. Mobility is DEGRADED when a tank can no longer maintain its position in the formation of which it is a part.

FIREPOWER KILL (F-KILL) - Loss of tactical firepower resulting from damage which cannot be repaired by the crew on the battlefield. A tank is considered to have sustained an F-Kill when it is incapable of delivering controlled fire from its main armament. Firepower is DEGRADED when a tank can no longer maintain its "normal" rate-of-fire, velocity, accuracy, time to shift targets, etc..

CATASTROPHIC KILL (K-KILL) - A tank is considered to have sustained a K-Kill when both an M-Kill and an F-Kill have occurred as the result of killing fires and explosions from ignited fuel and/or ammunition. A tank which has suffered a K-Kill is considered not to be economically repairable, and by U.S. standards, would be abandoned on the battlefield.

ATTACK ASPECT - The angle of approach of the aircraft with respect to the orientation of the target with 0° representing the centerline of the tank with the bow and gun forward and 180° representing the rear of the tank.

SIGNIFICANT DAMAGE - Damage to a target, component, or sub-system which results in a loss of function to the target, component, or sub-system and which contributes to the assessed mobility of fire power kill.

INSIGNIFICANT DAMAGE - Damage to a target, component, or sub-system which results in no loss of function and which makes no contribution to the overall kill. Good maintenance practices requires repair or replacement of such items at the earliest opportunity.

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| 31. | 354 TFW/DO
Myrtle Beach AFB, SC. 29577 | 2 |
| 32. | 23 TFW/DO
England AFB, LA. 71301 | 2 |

- | | | |
|-----|--|---|
| 33. | USAC 4SC
Ft. Leavenworth, Kansas 66027 | 1 |
| 34. | 355 TFW/DOW
Davis Monthan AFB, AZ. 85707 | 1 |
| 35. | 355 TFW/DO(A-7)
Davis Monthan AFB, AZ. 85707 | 1 |
| 36. | 355 TFW/DO(A-10)
Davis Monthan AFB, AZ. 85707 | 3 |
| 37. | 333 TFTS/CC
Davis Monthan AFB, AZ. 85707 | 1 |
| 38. | 333 TFTS/DO
Davis Monthan AFB, AZ. 85707 | 1 |
| 39. | 333 TFTS/WPNS (CAPT Haar)
Davis Monthan AFB, AZ. 85707 | 2 |
| 40. | AFTEC A-10 Test Force/CC
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52. USAF 2
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53. USAF 2
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& Development Plans
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55.	HQ TAC/DO O Langley AFB, VA. 23665	2
56.	HQ TAC/DOOO Langley AFB, VA. 23665	2
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59.	USAF Academy Library USAF Academy, Colo. 80840	2
60.	USAF TFWC/TA Nellis AFB, NV. 89191	1
61.	57 FWW/DO Nellis AFB, NV. 89191	1
62.	12 AF/DO Bergstrom AFB, TX. 78743	2
63.	9 AF/DO Shaw AFB, SC. 29152	2
64.	CINCUSAFE/DO Ramstein AFB APO 09012	1
65.	CINCUSAFE/DOOF Ramstein AFB APO 09012	2
66.	CINCUSAFE/DCOT Ramstein AFB APO 09012	2
67.	CINCUSAFE/DOST Ramstein AFB APO 09012	2